(54) Title: A METHOD AND APPARATUS FOR UPLINK SCHEDULING
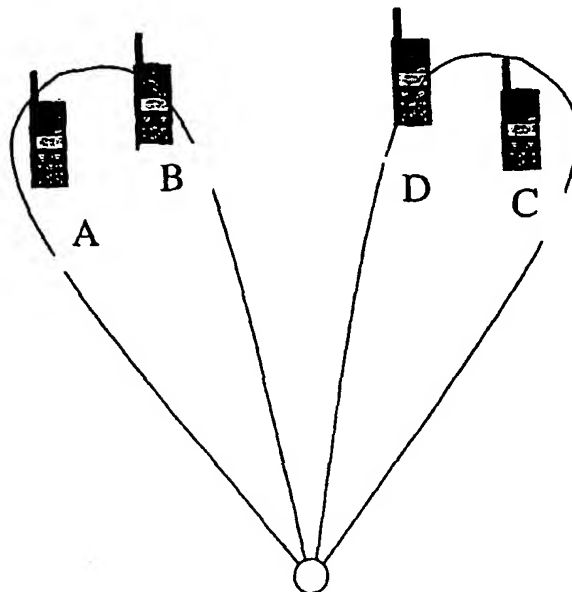
(57) Abstract: The present invention relates to methods for performing uplink scheduling of packet data when using adaptive an-
tennas. In the solution according to the invention the uplink scheduling information is transmitted in an antenna beam towards the
mobile for which the scheduling information is intended and by allocating mobile stations with similar position to the same packet
data channel. All other data packets are transmitted in an antenna beam towards the mobile station for which the data are intended.
By adopting the proposed solution it is possible to efficiently use adaptive antennas in a system carrying e.g. GPRS/EGPRS traffic.
The carrier to interference gain introduced by adaptive antennas produces a pronounced increase in system performance.

WO 01/31810 A1

A METHOD AND APPARATUS FOR UPLINK SCHEDULING

TECHNICAL FIELD OF THE INVENTION

The present invention relates generally to methods for using adaptive antennas in cellular mobile telephone systems, and more particularly the invention relates to a method for performing uplink scheduling of packet data when using adaptive antennas.

The invention also relates to an arrangement for carrying out the method.

BACKGROUND OF THE INVENTION

It is anticipated that a large part of the future growth of wireless communication will be data traffic. Due to the "burstiness" of data traffic, the spectrum is more effectively used if the users share a common resource. An efficient way of sharing a resource is to use packet data. Thus, a great effort has been made in standardising a protocol for transmitting packet data in a GSM mobile communication network. This protocol is called GPRS (General Packet Radio Service) with future enhancements in EGPRS (Edge GPRS).

The GPRS protocol enables more than one mobile station to use the same timeslot or timeslots. This is done by time multiplexing users on the same radio resource. When starting a transmission the mobile station is assigned one or more timeslots in up- and downlink. In the assignment the mobile stations are given a temporal bit flow identity (TFI) and an uplink state flag (USF). The TFI is attached to the data blocks in order to identify the terminating mobile station of the transmitted block. In the downlink all mobiles are listening to the assigned timeslots and try to decode all blocks but only considers the blocks with corresponding TFI's.

The preferred method for scheduling the uplink is to use the USF, which is attached to user data in a downlink block. A mobile station is allowed to transmit an uplink block on a following time slot or a number of following timeslots if it
5   detects its USF in the corresponding downlink block. This method is called dynamic assignment. Another method for scheduling the uplink is to use an entire downlink block, i.e. when a mobile station is signalling uplink channel request, the reply from the network is a bitmap telling the mobile station
10   what timeslots in what TDMA-frames the mobile station should use. The bitmap is transmitted to the mobile station in a dedicated data block. This method is called fixed assignment.

Adaptive antennas, here defined to be an antenna system that is able to change its characteristics to changes in the network,
15   have several interesting properties. One of the most important features of an adaptive antenna system is that the base station is able to detect the direction to the mobile station and can thus transmit dedicated information in an antenna beam towards a desired mobile station. An antenna beam is defined as any
20   signal transmission deliberately covering only a part of a cell, and a cell is defined as the total coverage area of a base station. This implies that the downlink signal is not transmitted in the entire cell resulting in lower interference in the system. Adaptive antennas have been shown to increase
25   the system downlink C/I as much as 6dB compared to a regular system using sector-antennas. The interference level generally determines the channel reuse patterns. Because the interference level is reduced a channel reuse pattern can be formed in which channels are reused more frequently, thus increasing the
30   capacity of the network. If the reuse pattern is left unchanged the C/I of the communication links is increased. Thus, the reduced downlink interference can be used either for increasing the number of users in the system or for increasing the C/I of the communication links.

The increased C/I of the communication links can in its turn be used to produce a significant throughput increase in a system carrying GPRS/EGPRS traffic. This is mainly due to link adaptation, which transforms communication link improvements into a throughput increase. In EGPRS a number of different coding schemes and two modulation methods are used to ensure maximum throughput at the current communication link quality C/I, i.e. the payload per transmitted data block varies with the quality of the communication link. A communication link having high quality can be used for a higher data transmission rate either by applying higher modulation or lower coding. Thus, it is obvious that there is a large potential in applying adaptive antennas in systems carrying GPRS/EGPRS traffic.

However, a problem exists with uplink scheduling when using adaptive antennas since user data and scheduling information usually terminates at different mobile stations. If the mobile stations are spatially separated there is a problem transmitting in an antenna beam since communication is optimised for only one of the mobile stations.

One possible solution of scheduling the uplink is found in WO-99/41918, which is especially advantageous with adaptive antennas, when all radio blocks on the downlink transmissions do not have to be broadcast to all users on a certain channel. Two possibilities are discussed first to use fixed allocation where the initial setup signalling specifies when users are allowed to transmit on the uplink. The second possibility is to transmit the scheduling information on a broadcast channel so that it is certain that the correct mobile station receives the scheduling information and transmit all other data blocks in antenna beams to the mobile stations for which the data is intended.

Another possible solution of forming antenna beams, which permit other remote communication stations to detect the

communication signals transmitted to a selected remote station, is described in WO-98/33233. More particularly the document solves the problem by using at least two antenna beams active at the same time to also cover mobile stations for which the transmission is not intended. The purpose is mainly to use the signal energy transmitted in the downlink for enabling complexity reduction in the mobile station and for facilitating the tracking of the downlink signal in a successive timeslot, such as e.g. in D-AMPS (Digital Advanced Mobile Phone System).

The solution according to WO-98/33233 has the disadvantages of having to use two antenna beams active at the same time causing interference and overhead. The main purpose is also not to perform uplink scheduling as in the present invention, but instead to use the signal energy received for, e.g. AGC (Automatic Gain Control) adjustments and for reducing the complexity in the mobile station.

There is a need for flexible and efficient solutions for uplink scheduling when using adaptive antennas.

SUMMARY OF THE INVENTION

The present invention thus provides a solution to the protocol problems concerning how to perform uplink scheduling of packet data when using adaptive antennas.

In the preferred uplink-scheduling mode of GPRS/EGPRS the scheduling information is attached to user data. It is likely that the user data and the scheduling information are terminated at different mobile stations. Hence, if the mobile stations are separated the communication does not reach every intended receiver of the data.

One object of the present invention is thus to provide uplink scheduling of packet data in a radio communication system using adaptive antennas.

Another object of the invention is to reduce the amount of overhead necessary for uplink scheduling of packet data in a communication system with adaptive antennas.

The above mentioned objects are achieved by transmitting the
5   data blocks containing scheduling information in an antenna beam towards the mobile station for which the scheduling information is intended and by scheduling mobile stations with similar position on the same radio resource, i.e. the same Packet Data Channel (PDCH). All other data blocks are
10 transmitted in an antenna beam towards the mobile station for which the data are intended.

In the first embodiment of the invention when the data blocks containing the scheduling information is transmitted in an antenna beam towards the mobile station for which the
15 scheduling information is intended, there is a risk for a larger block error probability at the mobile station for which the data is intended. However, an ARQ (Automatic Request for Retransmission) algorithm ensures that the data block is retransmitted if the mobile station cannot decode it correctly
20 and it is possible to use the data received by the mobile station but not decoded correctly by implementing incremental redundancy.

The embodiments of the invention can preferably be implemented by software code segments, and e.g. be stored in any of the
25 relevant nodes of a mobile communication system, such as a base station, a base station controller, a mobile services switching centre, a packet control unit etc.

By adopting the proposed solution it is possible to use adaptive antennas in a system carrying GPRS/EGPRS traffic. The
30 combination of the ARQ scheme and link adaptation of GPRS/EGPRS and the carrier to interference gain introduced by adaptive antennas produces a pronounced increase in system performance.

The term "comprises/comprising" when used in this specification is taken to specify the presence of stated features, integers,

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The above problem concerning uplink scheduling is basically solved by transmitting the data blocks containing scheduling information in an antenna beam towards the mobile station for which the scheduling information is intended and by allocating

5   mobile stations with similar positions or with radio paths with similar angle of arrival on the same radio resource, i.e. PDCH. This reduces the number of retransmitted frames since mobile stations for which data and scheduling information is intended are covered by the same antenna beam. The solution will be

10   further described with reference to figures 2-4.

Figure 2 shows in detail the radio block structure of the smallest entity in GPRS/EGPRS, the RLC/MAC-block. Each RLC/MAC-block consists of a MAC header, an RLC data block and a block check sequence (BCS). The MAC header comprises an uplink state

15   flag (USF) and the RLC data block consists of an RLC header, containing a block type indicator and power reduction fields, and RLC data. The RLC/MAC-block is channel coded, interleaved and mapped onto four normal GSM bursts. A mobile station thus has to receive all four bursts to receive the RLC/MAC-block.

20   The scheduling information is found in the USF, which gives the corresponding mobile station permission to transmit on the uplink.

According to the invention data blocks containing scheduling information is transmitted in an antenna beam towards the

25   mobile station for which the scheduling information is intended. Then there is of course a risk for a larger block error probability at the mobile station for which the user data is intended. However, an ARQ (Automatic Request for Retransmission) algorithm ensures that the data block is

30   retransmitted if the mobile station cannot decode it correctly, i.e. when an error in the BCS (Block Check Sequence) is detected. Some of the user data might still reach the mobile station for which it is intended because of radio reflections and side lobes from the main lobes. In figure 3 the side lobes

35   can be seen at approximately -14dB. A further feature of the

invention is to use information about the positions of the mobile stations in the scheduling algorithm in order to minimise the number of data blocks transmitted in an erroneous antenna beam. For example should mobiles that are not spatially

5 separated be multiplexed on the same packet data channel (PDCH), i.e. the same timeslot and frequency. This reduces the need for retransmissions, since both scheduling information and user data terminates at mobiles covered by the same antenna beam, and thus the system capacity increases.

10 More specifically, referring to figure 4, a simple example is shown. The figure shows four mobile stations which all have the capability of transmitting and receiving on two timeslots. Mobile stations A and B are clustered together and mobile stations C and D are clustered together. The inventive

15 algorithm would then allocate mobile stations A and B on the same PDCH and mobile stations C and D on the same PDCH.

In a first embodiment of the invention user data received by a mobile station but not decoded correctly can still be used to some extent due to incremental redundancy, i.e. the soft values

20 of the first received frame is used together with the soft values of a retransmitted frame. The retransmitted frame may have been coded in a different way, which further increases the information, thus more data can be correctly decoded.

The invention being thus described, it will be obvious that the

25 same may be varied in many ways. Such variations are not to be regarded as a departure from the scope of the invention, and all such modifications as would be obvious to a person skilled in the art are intended to be included within the scope of the following claims.

CLAIMS

1. A method for performing uplink scheduling of packet data in a mobile communication system that includes at least one base station transmitting to a plurality of mobile stations within
5 its respective area of coverage, the at least one base station using adaptive antennas in the method data blocks carrying scheduling information are transmitted from the base station in an antenna beam towards the mobile station for which the scheduling information is intended; and all other data blocks
10 are transmitted in an antenna beam towards the mobile station for which the data are intended

the method **characterised**

in that mobile stations covered by the same antenna beam are multiplexed on the same packet data channel.

15 2. The method of claim 1 **characterised** in that said scheduling information is a flag informing a mobile station that it has an uplink radio resource reserved.

3. The method of claim 2 further **characterised** in that said scheduling information is an uplink state flag.

20 4. The method of claim 3 further **characterised** in that said uplink state flag is of granularity 1 or 4.

5. The method of any of claims 1-4 further **characterised** by using incremental redundancy when decoding the data received in the mobile station for which user data was intended.

25 6. A computer program product comprising a computer readable medium, having thereon:

computer program code segments for performing the method of any of claims 1-5 when said product is run on a computer.

7. The computer program product according to claim 6 **characterised** in that it is stored in a scheduler.

8. A base station for performing uplink scheduling of packet data in a mobile communication system with a plurality of mobile stations in the coverage are of the base station, the base station comprising first means for transmitting data blocks carrying scheduling information in an antenna beam towards the mobile station for which the scheduling information is intended; and second means for transmitting all other data blocks in an antenna beam towards the mobile station for which the data are intended

the base station further **characterised** by

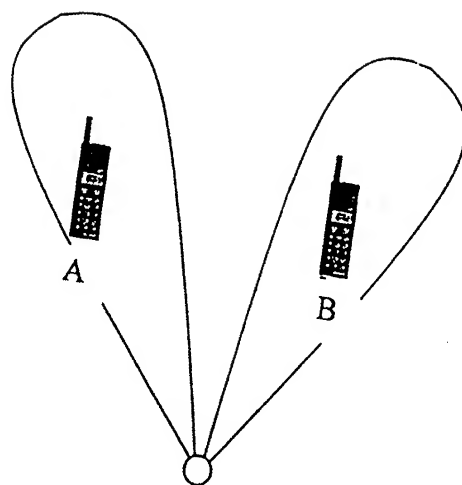means for multiplexing mobile stations covered by the same antenna beam on the same packet data channel.

Figure 1.

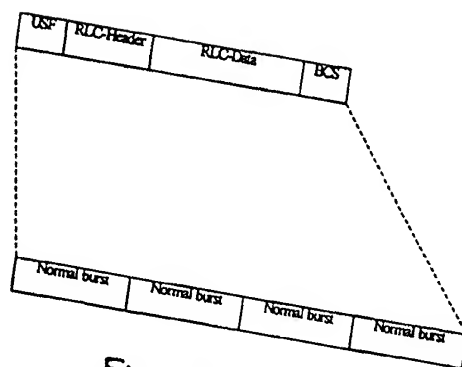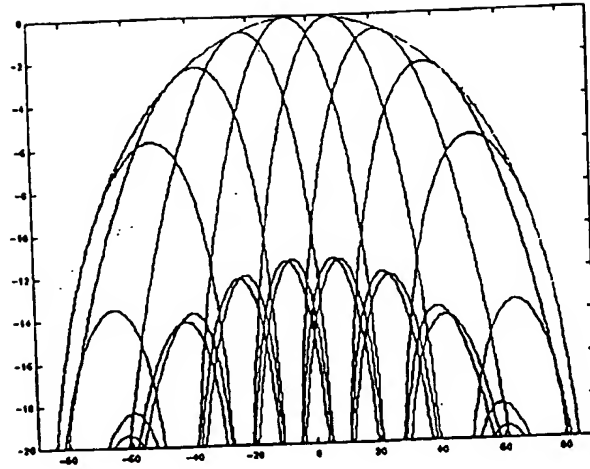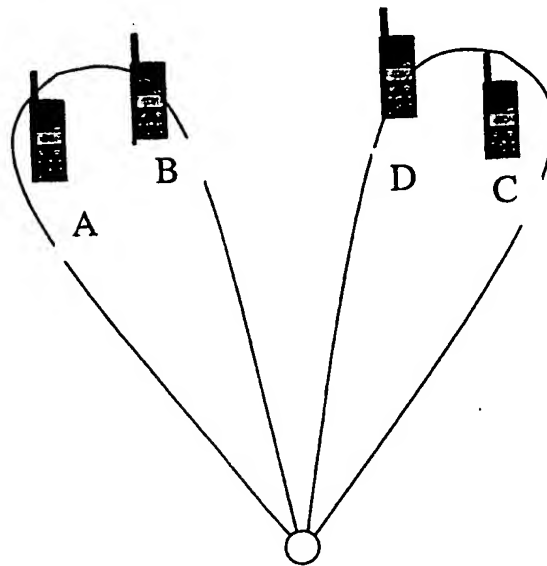| USF	RLC-Header	RLC-Data	BCS

| Normal burst | Normal burst | Normal burst | Normal burst |

Figure 2.

Figure 3.

Figure 4.